Toward Continuous Improvement of EAC/ABET Criteria 3 and 5

Dr. Norb Delatte P.E., Oklahoma State University

Dr. Norbert J. Delatte, Jr., P.E., is Professor and Head of the School of Civil and Environmental Engineering at Oklahoma State University. He is the author of Beyond Failure: Forensic Case Studies for Civil Engineers (ASCE Press, 2009). In addition, he is the Editor of ASCE's Journal of Professional Issues in Engineering Education and Practice. Dr. Delatte is a registered professional engineer in the States of Oklahoma, Ohio, and Alabama and in the Commonwealth of Virginia.

Dr. Stephen J. Ressler P.E., United States Military Academy

Stephen Ressler, P.E. Ph.D., Dist.M.ASCE, F.ASEE is Professor Emeritus from the U.S. Military Academy (USMA) at West Point. He earned a B.S. degree from USMA in 1979, a Master of Science in Civil Engineering from Lehigh University in 1989, and a Ph.D. from Lehigh in 1991. As an active duty Army officer, he served for 34 years in a variety of military engineering assignments around the world. He served as a member of the USMA faculty for 21 years, including six years as Professor and Head of the Department of Civil and Mechanical Engineering. He retired as a Brigadier General in 2013. He is a registered Professional Engineer in Virginia, a Distinguished Member of ASCE, and a Fellow of ASEE.

Dr. Audra N. Morse P.E., Michigan Technological University

Dr. Audra Morse, P.E., is a Professor and Department Chair in the Department of Civil and Environmental Engineering at Michigan Technological University. Her professional experience is focused on water and wastewater treatment, specifically water reclamation systems, membrane filtration and the fate of personal products in treatment systems. However, she has a passion to tackle diversity and inclusion issues for students and faculty in institutions of higher education.

Dr. Camilla M. Saviz P.E., University of the Pacific

Camilla Saviz is Professor and Chair of Civil Engineering at the University of the Pacific. She received B.S. and M.S. degrees in Mechanical Engineering from Clarkson University, an M.B.A. from the New York Institute of Technology, and a Ph.D. in Civil and Environmental Engineering from the University of California, Davis. She joined Pacific in 1999 and is a registered Professional Engineer in California.

Dr. Brock E. Barry P.E., U.S. Military Academy

Dr. Brock E. Barry, P.E. is Professor of Engineering Education in the Department of Civil and Mechanical Engineering at the United States Military Academy, West Point, New York. Dr. Barry holds a Bachelor of Science degree from Rochester Institute of Technology, a Master of Science degree from University of Colorado at Boulder, and a PhD from Purdue University. Prior to pursuing a career in academics, Dr. Barry spent 10-years as a senior geotechnical engineer and project manager on projects throughout the United States. He is a licensed professional engineer in multiple states. Dr. Barry's areas of research include assessment of professional ethics, teaching and learning in engineering education, nonverbal communication in the classroom, and learning through historical engineering accomplishments. He has authored and co-authored a significant number of journal articles and book chapters on these topics.

Toward Continuous Improvement of the ABET Criteria for Accrediting Engineering Programs

Purpose and Scope

The principal purposes of this paper are as follows:

- Assess the process used by the Engineering Accreditation Commission (EAC) to develop the most recent update to the EAC General Criteria 3 and 5.
- Recommend an improved criteria development process, which provides for systematic, future-focused updates of the non-harmonized General Criteria on a predictable recurring schedule.

To achieve these purposes, we first investigate the change processes employed by a wide range of different accrediting agencies, in order to identify best practices. We then summarize and analyze the criteria change processes that have been used by ABET since its inception—including the Engineering Criteria 2000 (EC2000) initiative and the recent update of EAC Criteria 3 and 5. We describe a recent initiative implemented by one ABET member society—the American Society of Civil Engineers (ASCE)—to update its six sets of ABET Program Criteria on a systematic eight-year cycle. We summarize the processes currently being used by other ABET member societies to update their Program Criteria. Finally, based on conclusions drawn from these analyses, we present a series of recommendations for the EAC to develop and implement future changes to the non-harmonized General Criteria, effectively applying the concept of continuous improvement to the criteria themselves.

Background: Recent Revisions to the ABET EAC Criteria

The ABET EAC develops and promulgates three sets of criteria for accrediting engineering programs [1]:

I. General Criteria for Baccalaureate Level Programs
II. General Criteria for Master's Level Programs
III. Program Criteria

The General Criteria for Baccalaureate Level Programs, which are applicable to undergraduate engineering programs in all disciplines, are organized into the following eight criteria [1]:

- Criterion 1 – Students
- Criterion 2 – Program Educational Objectives
- Criterion 3 – Student Outcomes
- Criterion 4 – Continuous Improvement
- Criterion 5 – Curriculum
- Criterion 6 – Faculty
- Criterion 7 – Facilities
- Criterion 8 – Institutional Support

ABET has classified Criteria 1, 2, 4, 7, and 8 as *harmonized criteria*—meaning that they are identical across the four commissions of ABET.* Conversely, Criteria 3, 5, and 6 are *non-harmonized criteria,* which are unique to each commission, due to the inherent differences between the engineering, engineering technology, computer science, and applied and natural science fields. Given that the EAC Criteria 3 and 5 address the student outcomes and curriculum requirements associated with the preparation of graduates for engineering practice, these non-harmonized criteria are most likely to require periodic updates, as industry needs change over time. The non-harmonized criteria are also somewhat easier to update than the harmonized criteria, because changes to the harmonized criteria require a consensus of all four commissions.

EAC Criteria 3 and 5 recently underwent a major update—the first major revision to the EAC General Criteria since the EC2000 initiative of the late 1990s [3]. The update also included some new definitions (e.g., for complex engineering problems and college-level mathematics), which are important to interpretation of the criteria. These new criteria, which went into effect in the 2019-20 accreditation review cycle, resulted from a ten-year process of study and development, focused primarily on fixing perceived problems with the old criteria [4], [5]. At this time, the EAC has announced no formal plans or processes for developing future updates to the EAC General Criteria.

Criteria Revision Processes Used by Accrediting Agencies Other than ABET

Academic accreditation can be characterized as a quality assurance process [6]. During accreditation, an external organization verifies the curricular content and educational processes at an academic institution or program. When the standards are met, the external organization offers accreditation. In many countries, direct control of educational accreditation is provided by governmental organizations. The United States is fairly unique in that private non-profit organizations are responsible for review and accreditation. However, the federal government retains some authority through the National Advisory Committee on Institutional Quality and Integrity (NACIQI) [7]. The NACIQI provides oversight of all education accrediting organizations and serves in an advisory capacity to the U.S. Secretary of Education [8]. Part of the responsibility of NACIQI is to publish a list of nationally recognized accrediting agencies for higher education [7].

Higher education accreditation is conducted at the regional, national, and program levels. It is not uncommon for a particular academic institution to hold regional accreditation, as well as either national or programmatic accreditation.

Regional accreditors include the Middle States Commission on Higher Education, the New England Association of Schools and Colleges (which is subdivided into the Commission on Institutions of Higher Education and the Commission on Technical and Career Institutions), the Northwest Commission on Colleges and Universities, the Higher Learning Commission (formerly the North Central Association of Colleges and Schools), the Southern Association of Colleges and Schools Commission on Colleges, and the Western Association of Schools and

* The four Commissions of ABET are the Engineering Accreditation Commission (EAC), Engineering Technology Accreditation Commission (ETAC), Computing Accreditation Commission (CAC), and Applied & Natural Sciences Commission (ANSAC) [2].

Colleges (which is subdivided into the Accrediting Commission for Community and Junior Colleges and the Accrediting Commission for Senior Colleges and Universities) [8]. Figure 1 is a regional accreditation map that defines the jurisdictions for each regional accrediting organization in the United States.

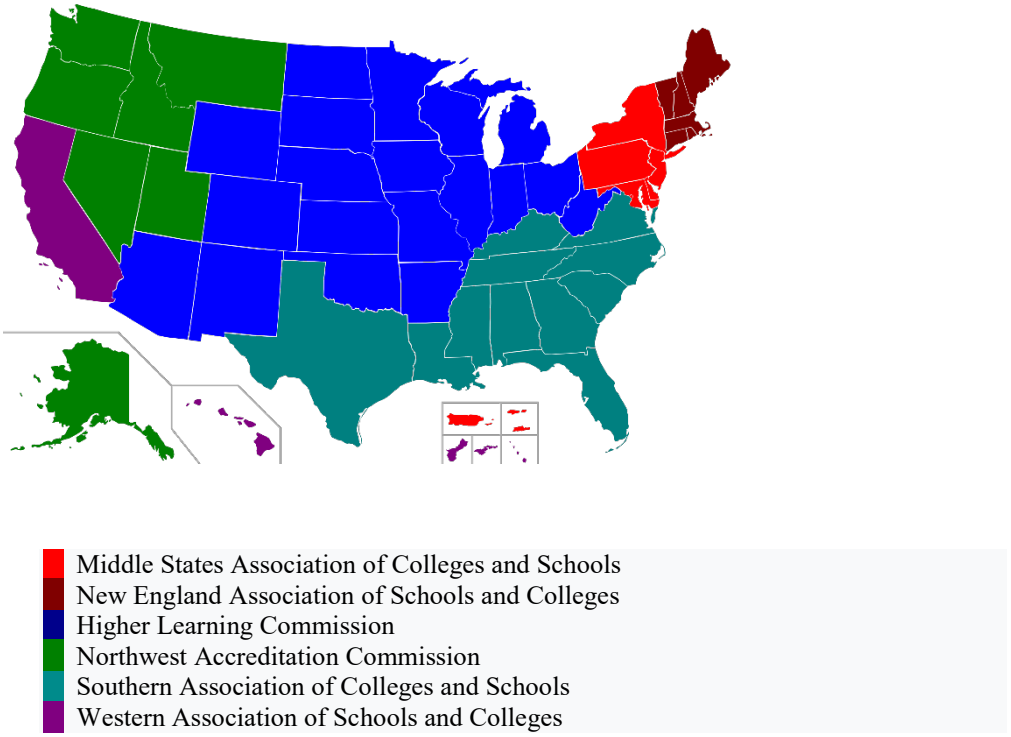

Figure 1. Regional Accreditation Map (Source: Creative Commons License)

The Board of Regents for the State of New York is also identified as a regional accreditor [9]. The Board accredits degree-granting academic institutions of higher education in the State of New York, but only for such institutions that identify the Board as the sole primary accrediting agency (predominantly State-funded universities) [9]. New York is grandfathered into this position and is the only state that is federally recognized as such [8].

Organizations that are classified as national accreditors typically offer accreditation on a nationwide or, in some cases, a worldwide basis. National accreditation is generally viewed as less rigorous than regional accreditation. For-profit academic institutions typically have national but not regional accreditation. Examples of national accreditors include the Accrediting Bureau of Health Education Schools, the Accrediting Commission of Career Schools and Colleges, the Accrediting Council for Continuing Education and Training, the Accrediting Council for Independent Colleges and Schools, the Distance Education Accrediting Commission, and the Council on Occupational Education [8].

Programmatic accreditation is discipline-specific and is typically associated with professional schools (e.g., business, medicine, law). The NACIQI recognizes a significant number of programmatic accreditation organizations including the American Bar Association Council of the

Section of Legal Education and Admission to the Bar, the American Dental Association, the National Accrediting Commission of Career Arts and Sciences, Inc., and Accreditation Council for Pharmacy Education [10].

It is very common for a college or university to have regional accreditation and at the same time have program-level accreditation within that college or university. For example, the University of Rochester (located in Rochester, New York) is accredited by the Middle States Association of Colleges and Schools (regional) and by the New York State Board of Regents (regional) [11], while the engineering programs within the university's Hajim School of Engineering are accredited by ABET [12].

Many programmatic accreditation organizations have established formal processes for updating their accreditation criteria. Unfortunately, not all such organizations provide details of these processes in readily accessible formats, such as websites. Thus, we contacted a large number of programmatic accreditation organizations and requested information about their processes. Below we provide summaries of the criteria revision processes used by five of these organizations in support of a wide range of professions. This was a sampling of convenience. Our intent in providing this information is not to present an all-encompassing summary, but rather to identify common characteristics of well-defined criteria revision processes used in a variety of different contexts.

- The American Council for Construction Education (ACCE) conducts a formal review of accreditation criteria used for bachelor of science and master of science programs in construction management on a three-year cycle. The review and revision process is conducted by construction industry professionals, construction industry associations, and teaching faculty with sufficient experience. The process is *not* conducted only using in-house staff. When reviewing accreditation criteria, the ACCE considers trends in construction technology as they relate to means and methods, societal and professional needs, and construction industry association recommendations and needs. [13]

- Prior to 2019, the criteria review and revision process used by the American Institute of Architects (AIA) was largely "haphazard and ad hoc" [14]. But effective January 1, 2019, the AIA's Standards for Continuing Education Programs [15] established a standardized review cycle of at least every two years. The Continuing Education Committee consists of nine AIA members and two representatives from AIA chapters and is responsible for reviewing and approving criteria revisions. AIA works closely with the National Council of Architecture Registration Boards (NCARB) to ensure that their accreditation criteria are aligned with regulatory and licensing requirements [14, 15]. Furthermore, AIA considers "best practices in adult learning and education" when reviewing and revising its criteria [15].

- The Accreditation Council for Business Schools and Programs (ACBSP) is a program-level accreditor, founded in 1988 with a focus on teaching and learning in business schools [16]. Requirements for ACBSP accreditation include seven separate standards and over one hundred individual criteria [17]. The standards are amended through a vote of the organization's membership. The criteria are amended by a vote of the three boards responsible for accreditation in those commissions (Associate Degree Board of

Commissioners, Baccalaureate/Graduate Degree Board of Commissioners, and the Accreditation Governance Board). Minor revisions are considered every six months at the Boards' meetings. Major revisions are considered on a ten-year cycle and are evaluated by a committee consisting of Board members, association staff, and volunteers from stakeholder organizations [17]. The most recent major revision started in 2017 and was implemented in 2019. This revision focused on meeting the future needs of members in a dynamic higher education environment [17].

- The Accreditation Council for Pharmacy Education (ACPE) was founded in 1932 as the national agency for the accreditation of professional degree programs in pharmacy [18]. Prior to 2003, the organization was known as the American Council of Pharmaceutical Education. The ACPE's most recent criteria revision process was initiated in 2012 and specifically involved changes to the Doctor of Pharmacy degree standards. The impetus behind these revisions was multifaceted, but included feedback from stakeholders, industry status reports, and changes in educational methods. The criteria were changed based on feedback from deans, open meetings, and web-based surveys administered to the pharmacy education and practice communities [18].

- The Planning Accreditation Board (PAB), founded in 1960 as the National Education Development Committee of the American Institute of Planners, accredits university programs leading to a bachelor's or master's degree in urban planning [19]. The PAB Policies and Procedure Manual details their process for standards revision. Proposals for amendments are accepted and considered on an on-going basis [20]. When proposals are received, the PAB immediately notifies representatives of stakeholder organizations, publishes a notice on the PAB website, and puts notifications in the printed material prepared by stakeholder organizations. Multiple rounds of public comments are gathered before revisions are sent to the Board for approval. In addition to the ongoing consideration of proposed amendments, the PAB uses a 5-year cycle for planned reviews of their accreditation standards [20]. The process for these planned reviews is similar to the process previously described for out-of-cycle amendment proposals.

Based on this diverse sample of programmatic accreditation organizations, we note the following four characteristics of high-quality criteria update processes that are particularly relevant to this paper:

- A well-structured review and update process is conducted by a diverse team of practicing professionals, industry representatives, and experienced faculty who provide perspectives *external to the accreditation organization*.
- The review and update process purposefully addresses the future needs of the served profession and industries, standards for professional licensure, and best practices in educational methods.
- The review and update process is conducted on a regular, predictable cycle of a specified number of years.
- Proposed criteria revisions are vetted by obtaining broad-based review and feedback from all relevant stakeholders.

Analysis of Processes Used to Update the ABET General Criteria

Unlike the accreditation organizations discussed above, ABET has not instituted a process of systematic, regularly scheduled updates to its accreditation criteria at any time since its inception.

The Engineers' Council for Professional Development (ECPD), the predecessor to ABET, was established in 1932 in response to industry concerns regarding the ability of engineering education to prepare engineers for professional practice. For several decades after its establishment, ECPD looked exclusively to one of its member societies—the Society for the Promotion of Engineering Education (SPEE), the forerunner of the American Society for Engineering Education (ASEE)—to set the curricular standards that were being enforced by ECPD program evaluators [21]. In effect, SPEE served as the unified "voice of engineering education" for ECPD [21]. This situation changed following the publication of the 1955 Grinter Report [22], which prompted the ECPD to institute its first set of quantitative standards for accreditation. In the succeeding years, "curricular standards were allowed to drift" as the expert influence of SPEE was gradually superseded by the competing interests of the ECPD's federated governance structure [21]. By 1980, when ECPD changed its name to the Accreditation Board for Engineering and Technology (subsequently to be changed to ABET, Inc.), engineering accreditation had become "more rigid and rule-bound," while "the accreditation criteria grew from a few paragraphs … to thirty-plus pages of fine print containing detailed prescriptions for required courses, credit hour distributions, numbers of faculty, and laboratory improvement plans [23]." This growth was largely ad hoc and sporadic; it did not follow a systematic process or a regular cycle.

In 1992, the ABET leadership established an Accreditation Process Review Committee, which held a series of stakeholder workshops to build consensus on the need for fundamental changes to the ABET EAC criteria [24]. These workshops included university presidents, engineering deans, engineering faculty, industry leaders, professional society representatives, and ABET itself [23]. Based on their input, quality control approaches such as Six Sigma, which focused on outcome assessment, shaped the development of a new generation of criteria, called Engineering Criteria 2000 (EC2000). Prior to this effort, outcome assessment was not widespread in K-12 or higher education, nor was it supported by regional accreditation organizations [25].

Following these stakeholder workshops, the ABET leadership established an ad hoc committee to conduct engineering accreditation reform. The EAC Criteria Committee did not invite input on the criteria and did not seek interaction with other committees, including the Assessment Committee. Thus, even though the big ideas embodied in EC2000 were derived from broad-based stakeholder input, the actual criteria were written and deliberated largely in a vacuum. During this time, disciplinary differences within the EAC made it difficult to develop consensus within the committee. Consequently, the criterion governing curriculum (now Criterion 5) and discipline-specific Program Criteria were used to address differences in disciplinary education expectations.

The EC2000 General Criteria received final approval by the ABET Board of Directors in November 1996. After a series of pilot studies, phase-in accreditation visits under the new

criteria were implemented during the 1998-99 accreditation cycle [24]. During the following decade, only minor ad hoc changes were made to these criteria.

In 2009, the EAC Criteria Committee established a Criterion 3 Task Force to evaluate Criterion 3 (Student Outcomes) of the EAC General Criteria [22]. Recognition of the need for changes to Criterion 3 came about as a result of experience with, and feedback on, ten years of accreditation reviews conducted under the EC2000-based criteria—which were judged to have reached "maturity" [2]. Additionally, the EAC Criteria Committee "… was receiving requests from constituent groups for additional outcomes to be included in Criterion 3. The EAC leadership was aware that each year a substantial percentage of the shortcomings cited were associated with Criterion 3 [3]."

The Criterion 3 Task Force was instructed to survey constituents about the EAC Criterion 3 outcomes and the accreditation process. Data collected in this survey focused primarily on problems that evaluators and programs were experiencing with the *existing* outcomes—e.g., difficulties and inconsistencies in assessing the "soft skill" outcomes such as life-long learning.

The EAC Criteria Committee reviewed the work of the Criterion 3 Task Force and incorporated additional constituent feedback into the development of draft revisions to Criterion 3. In doing so, the committee determined that revisions to Criterion 5 (Curriculum) would also be required. For example, "use of modern engineering tools," previously listed under Criterion 3(k), was deemed to be more appropriately included as a curriculum requirement under Criterion 5. The committee did not choose to consider possible revisions to the one remaining non-harmonized criterion—Criterion 6 (Faculty).

Once the draft revisions were completed, the task force sought feedback from potential stakeholders, including domestic (U.S.-based) and international undergraduate and graduate programs, employers, licensing boards, and professional societies [3]. Ultimately, the revised Criteria 3 and 5 were submitted for approval on first reading by the ABET Engineering Area Delegation (EAD) in October 2016 and received final approval the following year. The criteria were made publicly available with the 2017-18 Criteria for Accrediting Engineering Programs [5] and were implemented for accreditation visits starting in the 2019-20 review cycle [1]. It is noteworthy that the memo requesting approval by the EAD [2] does not identify the constituents that contributed to the criteria revision process, nor does it address a process by which future revisions to the General Criteria will be made.

This recent revision to the EAC General Criteria demonstrates the inherent challenges in developing accreditation criteria for engineering programs. Since its inception, ABET has been a delegate-based organization, and it is currently a federation of 35 member societies—professional and technical organizations representing the fields that ABET accredits [26]. Within this federated organization, updates to the EAC General Criteria require a consensus of the engineering member societies for any changes to the non-harmonized criteria (Criteria 3, 5, and 6) and a consensus of *all* member societies for any changes to the harmonized criteria (Criteria 1, 2, 4, and 8). The non-harmonized criteria are likely to require more frequent updates, because they more closely reflect changing industry needs. Yet any such changes require the engineering member societies to achieve a consensus on a single set of student outcomes

(Criterion 3), a single set of curriculum requirements (Criterion 5), and a single set of faculty qualifications (Criterion 6) that meet the needs of *all* programs and *all* students in *all* disciplines. Achieving this sort of consensus is extraordinarily difficult.

Moreover, as demonstrated in the processes used for both EC2000 and the recent revisions to EAC Criteria 3 and 5, the development of high-quality criteria requires broad, substantive input from *all relevant constituencies*, not just those actively involved in ABET governance. Based on the characteristics of high-quality criteria development processes used by other accrediting agencies (described above) and on problems observed in the recent ABET process, we suggest that a transparent, open, deliberate, and thorough criteria update process should be characterized by:

1. input from diverse and appropriately qualified representatives of industry, academia, the licensure community, and relevant professional organizations;
2. constituent input obtained *prior to* the development of draft criteria, in order to determine the substance of the proposed changes;
3. constituent feedback obtained *after* the development of draft criteria, to identify strengths and issues with the proposed wording of the draft;
4. conduct of the criteria update by a stand-alone task committee that is independent of the EAC (see discussion below);
5. a task committee composition that includes perspectives external to ABET—most importantly strategic thinkers and engineering education scholars who are able to discern the future needs of the engineering profession and address recent changes in education best practices;
6. a task committee process that is focused primarily on the future needs of the profession, while also addressing observed issues with the previous criteria; and
7. a task committee process that balances the need to accommodate curricular innovation with the establishment of rigorous standards that meet the needs of industry and the licensure community.

In our view, the process used by the EAC to develop the recent changes to Criteria 3 and 5 demonstrated significant shortcomings with respect to items 1, 2, 4, 5, 6, and 7 above. Other authors have expressed similar concerns [27]-[31]. Most importantly, the organization charged with researching and formulating the criteria changes was an internal task force of the EAC, which was more aligned with ABET and its operational concerns than with the strategic needs of the profession [21]. Moreover, the charge of this task force was an essentially backward-looking requirement "to clarify outcomes that historically programs had difficulty assessing" and to facilitate more efficient assessment processes [32].

As Matos, Riley, and Akera [21] have convincingly demonstrated:

> "EC 2000 was developed by a broad coalition that included the NSF and NAE, a broad group of industry employers, professional societies, and leaders from educational institutions. It resulted in a document that served as an aspirational statement for the direction of the profession at the turn of the century. However, a dozen years later, when the EAC directed a task force two levels down in the organization to review the learning outcomes, the focus shifted from the needs of

the profession to the operational demands of ABET and the preferences of institutions undergoing review."

Finally, we note that the EAC's process addressed only two of the three non-harmonized General Criteria. It might logically have addressed all three—Criteria 3, 5, and 6. In doing so, the EAC could have achieved a comprehensive, holistic update of all criteria that are unique to engineering accreditation.

In short, as a result of a flawed organization and process, the EAC missed a significant opportunity to address the future needs of the engineering profession more comprehensively and more effectively.

ASCE's Eight-Year Cycle for Program Criteria Updates

As noted above, each ABET commission develops and promulgates General Criteria (which are applicable to all programs the commission accredits) and Program Criteria (which are applicable only to programs with a specified program name). Each set of Program Criteria has one or more designated Lead Societies, which are directly responsible for developing and updating these criteria. Program Criteria are only allowed to address curricular topics and faculty qualifications [33].

Although all Program Criteria have at least one Lead Society, some Lead Societies are responsible for more than one set of Program Criteria. For example, ASCE is the Lead Society for Program Criteria in six different curricular areas—Architectural Engineering, Civil Engineering, Construction Engineering, Architectural Engineering Technology, Civil Engineering Technology, and Construction Engineering Technology. Some Program Criteria are jointly controlled by more than one professional society. For example, the Materials, Metallurgical, Ceramics Program Criteria have one Lead Society for Materials and Metallurgical Engineering Programs (The Minerals, Metals & Materials Society, TMS) and one for Ceramic Engineering Programs (American Ceramic Society, ACerS).

Starting in 2002, the American Society of Civil Engineers (ASCE) embarked upon an educational initiative that would ultimately lead to the establishment of a regularly scheduled, systematic process for updating the six sets of Program Criteria for which ASCE serves as Lead Society.

This process began with the development of the Civil Engineering Body of Knowledge (CEBOK), which defines the knowledge, skills, and attitudes necessary to exercise responsible charge in the practice of civil engineering. The first edition of the Civil Engineering Body of Knowledge (CEBOK1) was published in February 2004 [34]. In conjunction with this process, ASCE also determined that attainment of the outcomes articulated in the CEBOK1 could best be promoted through the development of appropriate ABET accreditation criteria [35]. A stand-alone ASCE accreditation task committee was established to develop new EAC Civil Engineering Program Criteria, which were intended to support attainment of the CEBOK1 outcomes without being overly prescriptive. The task committee completed its work in early 2006 and submitted its proposed Program Criteria for approval by the EAC in July 2006 and by

the ABET Board of Directors in October 2006. After the requisite year of public review, these criteria received their final approval by the ABET Board in October 2007 and were first implemented for accreditation visits in the fall of 2008.

In the meantime—even as the formulation of these new CEBOK1-based Program Criteria was just getting underway—it became apparent that significant updates to the CEBOK1 would be required. These revisions were driven by:

- aspects of the CEBOK1 outcomes that did not lend themselves to effective measurement and assessment;
- publication of several strategic vision documents that called for future engineers to develop certain knowledge, skills, and attitudes that had not been addressed in the CEBOK1 outcomes [36], [37]; and
- continuing changes in the global civil engineering professional environment (e.g., a dramatic increase in the importance of sustainability).

As a result, a second edition of the Civil Engineering Body of Knowledge (CEBOK2) was initiated in October 2005 and published in February 2008 [38]. Among the most important changes incorporated into the CEBOK2 were:

- an increase in the number of outcomes from 15 to 24 and
- the use of Bloom's Taxonomy as the basis for defining the required level of achievement for each outcome. [39]

Both of these changes suggested that further modifications to the EAC Civil Engineering Program Criteria would be required.

The sequence of events described above is summarized in Table 1, which lists events associated with the CEBOK-1 and CEBOK-2 in separate columns. Note that the CEBOK2 was published seven months *ahead* of the first accreditation visits under CEBOK1-based Program Criteria—an unintentional disconnect that caused considerable confusion and concern among civil engineering department heads throughout 2008. Some department heads moved aggressively to implement the CEBOK2 outcomes in their curricula but worried that they would still be evaluated under CEBOK1-based criteria. Many other department heads remained focused on CEBOK1 but worried that new CEBOK2-based criteria would be forthcoming *before* the CEBOK1-based criteria had been fully implemented. Both of these perspectives were entirely reasonable responses to a poorly managed change process.

By mid-2008, the need for better synchronization of the process for developing new editions of the CEBOK and their associated accreditation criteria had become quite clear. The following year, ASCE responded by developing and publishing a long-term schedule for managing this process [40]. This schedule was based on three fundamental premises, derived from ASCE's experiences since 2002:

- Recognizing that changes in the civil engineering professional environment will continue to occur, the CEBOK must be systematically reviewed and updated on a regular basis.
- Recognizing that the accreditation process is ASCE's most effective tool for promoting attainment of the CEBOK, the EAC Civil Engineering Program Criteria must be appropriately synchronized with the CEBOK.

- Implementation and long-term management of the CEBOK will be greatly enhanced by providing more *predictability* in the change process.

DATE	EVENT	
	CEBOK, 1st Edition	**CEBOK, 2nd Edition**
June 2002	CEBOK1 committee organized	
November 2003	CEBOK1 finalized	
January 2004	Accreditation task committee organized	
February 2004	CEBOK1 published	
October 2005		CEBOK2 committee organized
February 2006	Draft CEBOK1-based CE Program Criteria published	
July 2006	CEBOK1-based CE Program Criteria approved by EAC (1st reading)	
October 2006	CEBOK1-based CE Program Criteria approved by ABET Board (1st reading)	
November 2006	Public review of CE Program Criteria initiated	
July 2007	CEBOK1-based CE Program Criteria approved by EAC (2nd reading)	
October 2007	CEBOK1-based CE Program Criteria approved by ABET Board of Directors (2nd reading)	
November 2007		CEBOK2 finalized
February 2008		CEBOK2 published
September 2008	First accreditation visits under CEBOK1-based CE Program Criteria	

Table 1. Sequence of events in the development of CEBOK1, CEBOK1-based accreditation criteria, and CEBOK2

Consistent with these premises, ASCE has developed and institutionalized a ***fixed eight-year cycle*** for implementation of all future updates of the CEBOK and EAC Civil Engineering Program Criteria. The use of an eight-year cycle was based on the following considerations:

1. As Table 1 suggests, the period of time required to formulate and publish a new edition of the CEBOK is between two and three years.
2. The period of time required to formulate, publish, gain approval of, and implement new ABET Program Criteria is approximately four years.
3. The period of time required for all ABET-accredited engineering programs to be evaluated under a new set of criteria is six years.

Based on (1) and (2), the total time required to develop a CEBOK update and its associated Program Criteria change is between six and seven years. Thus, a six-year change cycle would be feasible; however, because this would also correspond to the six-year ABET accreditation cycle, the same set of civil engineering programs would always be the first to experience accreditation

criteria changes. Thus, a six-year cycle would place an undue burden on these programs. ASCE's eight-year cycle was intended to address this issue, while also providing some additional flexibility in the development process, e.g., to accommodate publication delays or lack of funding in a given year.

ASCE's eight-year cycle is presented in Table 2. This schedule was developed by adding eight years to the implementation of CEBOK1-based accreditation criteria (September 2008), to obtain the target date for implementation of CEBOK2-based criteria (September 2016). All remaining milestones were derived from this date, using the experience-based time intervals and due dates. To date, this schedule has been followed with only minor variations, and ASCE remains committed to following it in the future.

Event	CEBOK 2nd Edition	CEBOK 3rd Edition	CEBOK 4th Edition
CEBOK committee organized	Accomplished at time of schedule development	October 2016	October 2024
CEBOK finalized		December 2018	December 2026
CEBOK published		March 2019	March 2027
Accreditation task committee organized	October 2012	October 2020	October 2028
Draft CE Program Criteria published	March 2014	March 2022	March 2030
CE Program Criteria approved by ABET EAC (1st reading)	July 2014	July 2022	July 2030
CE Program Criteria approved by ABET Board of Directors (1st reading)	October 2014	October 2022	October 2030
Public Review of CE Program Criteria initiated	November 2014	November 2022	November 2030
CE Program Criteria approved by ABET EAC (2nd reading)	July 2015	July 2023	July 2031
CE Program Criteria approved by ABET Board of Directors (2nd reading)	October 2015	October 2023	October 2031
First Reviews Under New CE Program Criteria	September 2016	September 2024	September 2032

Table 2. ASCE's long-term schedule for CEBOK and CE Program Criteria development

As indicated in Table 2, the ASCE process includes the appointment of a special stand-alone task committee to review and revise the Civil Engineering Program Criteria [41], [42]. The Task Committee includes members who serve in ABET Governance, but by design, also includes broad representation that includes civil engineering department heads, members of ASCE educational committees, and practitioners. Civil Engineering Program Criteria review and revisions are *never* performed by a standing committee because, in ASCE's experience, a standing committee is already fully engaged with its operational mission and thus typically cannot mobilize the time or strategic perspective necessary for criteria development.

At key points in the task committee's review process, input is sought from stakeholders across the educational and professional civil engineering communities. This approach yields a systematic review and, as needed, revision of the CEBOK and Civil Engineering Program Criteria, such that ASCE can address changes in the civil engineering profession while also being responsive to the needs of the educational institutions tasked with preparing future civil engineers.

The principal beneficiaries of this 8-year change cycle are civil engineering programs. With the implementation of criteria changes restricted to specific years (e.g., 2016, 2024, 2032), these programs are able to schedule routine reviews and updates of their Program Educational Objectives and Student Outcomes during these same years. Curriculum modifications and subsequent assessment of the revised outcomes can then be accomplished with a reasonable assurance of "closing the loop" before any new criteria changes occur. Thus, predictability enhances the effectiveness of change management.

In 2019, given the success of the 8-year change cycle for Civil Engineering Program Criteria, ASCE instituted similar 8-year cycles for its other five sets of Program Criteria.

Other Professional Societies' Processes for Updating Program Criteria

Having analyzed ASCE's successful process for Program Criteria updates, we administered a survey to members of the EAC Criteria Committee to determine whether their respective professional societies have implemented comparable processes. The survey consisted of the following questions:

1. Has your society developed a procedure for periodic review and update of the Program Criteria you are responsible for?
2. If yes, please provide a copy of your current process.
3. If not, are you considering developing a periodic review process?
4. If not, what, if anything, triggers changes to the Program Criteria you are responsible for?

Fifteen societies responded, and their responses are summarized in Table 3. ASCE is listed but described above. Our observations about the other societies' feedback are as follows:

- The American Institute of Chemical Engineers (AIChE) has a review process that is undertaken approximately every ten years. A committee proposes changes that are reviewed and edited by the AIChE Education and Accreditation Committee, which are also reviewed by department chairs at the annual society meeting. This approximate ten-year interval is also used by some other societies, such as the American Academy of Environmental Engineers and Scientists (AAEES), the American Ceramic Society (ACerS), and the Minerals, Metals, & Materials Society (TMS).

- Unlike other societies, where accreditation is one of many professional activities, CSAB focuses solely on accreditation of computing and related programs [43]. CSAB serves as the Cooperating Society for Computer Engineering programs and as Lead Society for all programs accredited under the Computing Accreditation Commission. The CSAB Criteria Committee has responsibility for developing, maintaining, and soliciting public

feedback on Program Criteria, as well as recommend Program Criteria updates for approval by the CSAB Board. CSAB currently does not have plans to establish a formal periodic review of Program Criteria because the computing fields change too quickly. Instead, they rely on committee members and the CSAB volunteer community to identify any concerns about, or suggest potential improvements to, each set of criteria.

- The Biomedical Engineering Society (BMES) has not used a formal periodic review process in the past but is implementing one now [44]. The American Institute of Aeronautics and Astronautics (AIAA) and the Society of Naval Architects and Marine Engineers (SNAME) stated that they were considering developing a review process. Four others, (International Council on Systems Engineering (INCOSE), the International Society for Optics and Photonics (SPIE), TMS, and ACerS, stated that they were not.

- Like ASCE, the AAEES bases its Program Criteria on a formally defined Body of Knowledge (BOK). The AAEES Environmental Engineering BOK was last updated in 2009. A new update is in process and is expected to be published in 2020. AAEES does not currently have any formal written procedure that requires a review of the Environmental Engineering Program Criteria with every BOK update, but the AAEES Education Committee has followed that procedure informally. The committee also responds to ABET and EAC updates, which might prompt Program Criteria changes.

Among the survey respondents, the following were identified as bases for initiating changes to Program Criteria:

- Suggestions from PEVs, Program Chairs, Society Committee responsible for ABET Liaison, Society Commissioners present and past (AIAA).
- Feedback from ABET, an Education and Accreditation Committee, or the chemical engineering community (AIChE).
- Feedback from program heads and discussion among society reps (SNAME)
- Suggestions from PEVs (SPIE).
- Ad hoc review whenever substantial changes take place in industry to warrant the change. (ASME).
- Compliance with ABET requirements (TMS).

In summary, only one-third (5 of 15) of the responding ABET member societies have implemented formal periodic Program Criteria update processes, with review cycles ranging from eight to ten years. For many societies, the principal triggers for initiating revisions are external and reactive—e.g., response to ABET changes, ad hoc input from program evaluators or program chairs, and new developments in industry.

Society and Applicable Program Criteria	Has procedure for systematic update of Program Criteria	If no, considering review process	Frequency of review	Basis for changes to Program Criteria	Entity responsible for changing Program Criteria
AAEES, Environmental	Yes		Approx. 10 yrs	AAEES BOK	AAEES Education Committee
ACerS, Materials, Metallurgical, Ceramics	No		Approx. 10 yrs	Acers/ TMS coordination	
AIAA, Aerospace	No	Yes		Comments from PEVs, Program Chairs, Society Committee responsible for ABET Liaison, Society Commissioners present and past.	
AICHE, Chemical, Biochemical, Biomolecular	Yes		10 years	Changes are typically triggered by feedback from ABET, an AICHE Committee, or the chemical engineering community	
ASABE, Agricultural	Yes			ASABE annual meetings	
ASCE, Architectural, Civil, Construction	Yes		8 years	Systematic review and revision of CEBOK	Task Committee that reports to the ASCE Committee on Accreditation
ASHRAE, cooperating for Architectural	N/A	N/A			
ASME, Mechanical	No	No		Technological changes (e.g., digital age, artificial Intelligence, advanced or smart manufacturing, nano materials)	
BMES, Bioengineering and Biomedical	No	Yes	None since 2013	Review at annual meeting	
CSAB, Software	No	No		Changes to technology	CSAB Criteria Committee
IEEE, Electrical, Computer, Communications, Telecommunication(s)	Yes			Each January and July at CEAA (Committee for EAC programs) and CETAA (Committee for ETAC programs) committee meetings.	
INCOSE, Systems	No			Still working on initial criteria requirements	
SNAME, Naval Architecture and Marine Engineering	No	Yes	Ad hoc	Feedback from program heads and discussion among society reps.	
SPIE, Optical and Photonic	No	No	Ad hoc	Any changes to Program Criteria have been initiated by PEVs.	Education Committee
TMS, Materials, Metallurgical, Ceramics	No		Approx. 10 yrs	Acers/ TMS coordination	

Table 3. Summary of processes used by Lead Societies to update Program Criteria

Conclusions

Based on the analyses described above, we draw the following principal conclusions:

- Since its inception, ABET has implemented major changes to its accreditation criteria using widely varying and largely ad hoc processes.

- The recent revision of EAC General Criteria 3 and 5 was compromised by a flawed development process. The organization charged with researching and formulating the criteria changes was an internal subcommittee of the EAC. The subcommittee's charge was an essentially backward-looking requirement to fix perceived problems with the old Criterion 3 outcomes, rather than addressing the future needs of the engineering profession from a broader strategic perspective. The process would have been more effective if it had been implemented by a stand-alone task committee that included perspectives external to ABET—most importantly strategic thinkers and engineering education scholars who were better able to discern the future needs of the profession and new developments in educational methods.

- ASCE's implementation of a systematic 8-year change cycle for Program Criteria updates has been highly effective.

- Only a minority of other ABET member societies have instituted similar processes for their Program Criteria updates.

Recommendations

Consistent with the spirit of EAC Criterion 4 (Continuous Improvement), adoption of a well-documented, systematic, regularly scheduled process for the review of the EAC General Criteria would help ensure that the criteria reflect the changing needs of the engineering profession while also allowing programs to plan for change. To achieve this end, we recommend that the ABET EAC take the following actions:

- Establish a long-term schedule of systematic changes to the non-harmonized EAC General Criteria (Criteria 3, 5, and 6), planned and implemented on a regular, predictable cycle.

- For each scheduled criteria change, establish a stand-alone task committee, external to the EAC and consisting of a diverse team of well-qualified experts from both industry and academia, strategic thinkers who can ascertain the future needs of the engineering profession, and carefully selected representatives of the EAC's other constituencies.

- Develop a task committee charge that emphasizes scholarly research to determine the future needs of the engineering profession, rigorous analysis, collaborative decision-making, and thorough public documentation and communication of work products;

- Develop and implement open processes for seeking input on criteria requirements and for obtaining feedback on draft criteria.

- Clearly document and publicize the schedule, task committee charge, and development processes, such that they can be understood and embraced by ABET's member societies and can be continuously improved.

- Encourage all ABET member societies to develop similar schedules and processes for periodic updates to their Program Criteria.

The most important feature of this series of recommendations is the *predictability of the review cycle*, which will facilitate planning for, and management of, changes in programs and curricula—and thus will support the long-term improvement of engineering programs.

Acknowledgement

In support of this research, we requested information about the internal Program Criteria change processes used by the professional societies that currently serve as members of the ABET Engineering Accreditation Commission (EAC) Criteria Committee. We are deeply grateful to the representatives of the following societies for their thoughtful responses: American Academy of Environmental Engineers and Scientists (AAEES), American Ceramic Society (ACerS), American Institute of Aeronautics and Astronautics (AIAA), American Institute of Chemical Engineers (AICHE), American Society of Agricultural and Biological Engineers (ASABE), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), American Society of Mechanical Engineers (ASME), Biomedical Engineering Society (BMES), CSAB, Institute of Electrical and Electronics Engineers (IEEE), International Council on Systems Engineering (INCOSE), Society of Naval Architects and Marine Engineers (SNAME), The International Society for Optics and Photonics (SPIE), and The Minerals, Metals, & Materials Society (TMS).

References

[1] EAC/ABET, Criteria for Accrediting Engineering Programs, 2019 – 2020, https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/ [Accessed December 2019].

[2] https://www.abet.org/about-abet/governance/ [Accessed January 2020].

[3] S. Rajala, Memorandum to ABET Engineering Area Delegation, "Proposed Revisions to the *Criteria for Accrediting Engineering Programs* General Criteria Introduction, Criterion 3. Student Outcomes, and Criterion 5. Curriculum – First Reading," https://www.abet.org/wp-content/uploads/2015/11/Recommended-Motion-EAC-Chair.pdf [Accessed December 2019].

[4] "Rationale for Revising Criteria 3 and 5," https://www.abet.org/accreditation/accreditation-criteria/accreditation-changes/rationale-for-revising-criteria-3/ [Accessed December 2019].

[5] Criterion 3 Revision Timeline," https://www.abet.org/criterion-3-revision-timeline/ [Accessed December 2019].

[6] M. Peace Lenn, "The globalization of the professions and higher education: trade agreements, new technologies and the quality imperative," *Higher Education in Europe*, 21 (4), pp. 89-96, 1996.

[7] National Advisory Committee on Institutional Quality and Integrity – Authority. (n.d.). Retrieved from https://sites.ed.gov/naciqi/authority/ [Accessed December 2019].

[8] United States Department of Education – Institutional Accrediting Agencies. Retrieved from https://www2.ed.gov/admins/finaid/accred/accreditation_pg6.html#RegionalInstitutional [Accessed December 2019].

[9] New York State Education Department – Institutional Accreditation by the Board of Regents. (n.d.). Retrieved from http://www.nysed.gov/college-university-evaluation/institutional-accreditation-board-regents [Accessed December 2019].

[10] United States Department of Education – Programmatic Accrediting Agencies. (n.d.). Retrieved from https://www2.ed.gov/admins/finaid/accred/accreditation_pg7.html#RegionalInstitutional [Accessed December 2019].

[11] University of Rochester – University Accreditations. (2019). Retrieved from https://www.rochester.edu/bulletin/about/accreditations/index.html [Accessed December 2019].

[12] Hajim School of Engineering, University of Rochester. (2019). Retrieved from https://www.hajim.rochester.edu/ [Accessed December 2019].

[13] K. Siddiqi, (personal communication, January 11, 2020).

[14] S. Martin, (personal communication, December 30, 2019).

[15] American Institute for Architects, "Standards for Continuing Education Programs," October 2018.

[16] ACBSP – Who We Are. (n.d.). Retrieved from https://www.acbsp.org/default.aspx [Accessed December 2019].

[17] S. Parscale, (personal communication, December 18, 2019)

[18] Accreditation Council for Pharmacy Education (2015). *Accreditation standards and key elements for the professional program in pharmacy leading to the doctor of pharmacy degree*, 2015.

[19] Planning Accreditation Board. Retrieved from https://www.planningaccreditationboard.org/index.php?s=ProgramChairsEducators [Accessed December 2019].

[20] Planning Accreditation Board. *Policies and Procedures Manual, 2019.*

[21] S. M. Matos, D. M. Riley, and A. Akera, "WannABET? Historical and Organizational Perspectives on Governance in Engineering Education," *Proceedings of the 2017 ASEE Annual Conference*, 2017.

[22] "Report of the Committee on Evaluation of Engineering Education." (1955-1956). *Journal of Engineering Education*, 46, 26-60.

[23] John W. Prados, "ABET Engineering Criteria 2000: How We Got There and Why," *Proceedings of the 2017 ASEE Annual Conference*, 1997.

[24] Kurt C.K. Lo, "Engineering Program Accreditation: ABET Engineering Criteria 2000," *Proceedings of International Conference on Engineering Education,* iNEER, 2000.

[25] A. Akera, S. Appelhans, A. Cheville, T. De Pree, S. Fatehiboroujeni, J. Karlin, D. Riley, "ABET & Engineering Accreditation - History, Theory, Practice: Initial Findings from a National Study on the Governance of Engineering Education," *Proceedings of the 2019 ASEE Annual Conference*, 2019.

[26] "ABET Member Societies," https://www.abet.org/member-societies/ [Accessed March 2020].

[27] A. Akera, "The Historical and Structural Context for the Proposed Changes to ABET Accreditation Criteria," *Proceedings of the 2016 ASEE Annual Conference*, 2016.

[28] D. Riley, "Mind the Gap: What the ABET Crisis Can Teach us about Connecting Research and Practice," ERM Distinguished Lecture, ASEE Annual Conference, June 29, 2016.

[29] H. J. Passow and C. H. Passow. "What Competencies Should Undergraduate Engineering Programs Emphasize? A Systematic Review," *Journal of Engineering Education*, vol. 106, no.3, pp. 475–526, July 2017.

[30] C. D. Matt, "NAE Forum on Proposed Revisions to ABET-EAC General Criteria on Student Outcomes and Curriculum," WEPAN, February 16, 2016.

[31] S. G. Walesh, "Proposed Revisions to ABET General Criteria 3 and 5: A Practitioner's Perspective," presented at the Forum on Proposed Revisions to ABET Engineering Accreditation Commission General Criteria on Student Outcomes and Curriculum (Criteria 3 and 5), National Academy of Engineering, Washington, DC, February 16, 2016.

[32] Susan Conry, "C3&5 Summary—What Changed," EAC Criteria Committee, unpublished working paper provided by J. Sussman, February 14, 2016.

[33] Sebern, M. and Plasker, J. "Initial Report on EAC Program Criteria Compliance," prepared for the EAC Executive Committee, October 15, 2018.

[34] Body of Knowledge Committee of the Committee on Academic Prerequisites for Professional Practice. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future.* Reston, VA: American Society of Civil Engineers, 2004.

[35] S. J. Ressler, "Influence of the New Civil Engineering Body of Knowledge on Accreditation Criteria," *Proceedings of the 2008 ASEE Annual Conference*, 2008.

[36] National Academy of Engineering. *The Engineer of 2020: Visions of Engineering in the New Century*, National Academies Press, Washington, D.C., 2004.

[37] Task Committee to Plan a Summit on the Future of the Civil Engineering Profession. *The Vision for Civil Engineering in 2025—Based on the Summit on the Future of Civil Engineering, June 21 – 22, 2006*. Reston, VA: American Society of Civil Engineers, 2007.

[38] ASCE. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future*, *2nd Edition,* Reston, VA, 2008.

[39] Bloom, Benjamin S. *Taxonomy of Educational Objectives*, New York: Longman, 1956.

[40] S. J. Ressler and D. Lynch, "The Civil Engineering Body of Knowledge and Accreditation Criteria: A Plan for Long-Term Management of Change," *Proceedings of the 2011 ASEE Annual Conference*, 2011.

[41] A. C. Estes and T.A. Lenox, "New Civil Engineering Program Criteria: How the Sausage is Being Made," *Proceedings of the 2014 ASEE Annual Conference*, 2014.

[42] A. C. Estes, T.A. Lenox, and R.O. Anderson, "New Civil Engineering Program Criteria: The Rest of the Story," *Proceedings of the 2015 ASEE Annual Conference*, 2015.

[43] CSAB Inc. (CSAB) http://www.csab.org/ [Accessed March 2020].

[44] Michele J. Grimm, personal email communication.